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Russian-Dutch Project “3D Cadastre Modelling in Russia”

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Key words: 3D cadastre, multilevel complex buildings, subsurface, 3D viewer, pilot

SUMMARY

This paper presents results of the Russian-Dutch project on 3D cadastre modelling in the Russian Federation. The purpose of the project was to assess added value of a 3D cadastre for better registration and recording of (rights regarding) multilevel complex buildings and constructions, and subsurface networks such as gas pipelines. The project included prototype development and a pilot with use cases selected in Nizhny Novgorod, Nizhegorodskaya Oblast.

Experts from Rosreestr (Russian Federal Service for State Registration, Cadastre and Cartography) central and local offices, cadastral chambers, technical inventory offices and cadastral engineers participated in the pilot. The pilot was evaluated based on a structured questionnaire, with topics organised in various categories: general, legal aspects, spatial aspects, information dissemination aspects, etc.

The pilot was conducted after the completion of the design of a 3D cadastral model (ISO FDIS 19152, LADM based) and the development of a web-based prototype for 3D cadastral visualisation. The prototype consists of a 3D viewer that shows the cadastral objects in 3D space, and permits to make selections on e.g. cadastral number, name of the owner, number of rooms etc.

The 3D cadastre 'investigation project' in the Russian Federation ended in July 2012. Based on the positive experiences from the project in general and the pilot in specific, recommendations for the future introduction of 3D cadastre have been formulated, including improvements in the Russian legal framework and the organisation of 3D cadastre.

The next step can be to apply the recommendations to an operational real-world situation. For the technical preconditions a production environment with more functionality should be developed, including: a validator, DBMS data storage, on-the fly creation of the 3D objects from a data stream obtained from the database, and an extension of the 3D viewer to show also neighbour units in 3D.

РЕЗЮМЕ

В работе представлены результаты российско-нидерландского проекта “Создание модели 3D кадастра в России”. Цель проекта заключалась в оценке использования 3D-кадастра для улучшения регистрации и кадастрового учета многоуровневых сложных объектов (зданий и сооружений) и подземных сетей, таких как газопроводы. Проект включал разработку прототипа и его тестирование с использованием примеров, выбранных в Нижнем Новгороде (Нижегородская область).

В испытании прототипа участвовали эксперты центрального аппарата и территориального управления Росреестра (российской Федеральной службы государственной регистрации, кадастра и картографии), кадастровой палаты, бюро технической инвентаризации и кадастровые инженеры. Результаты оценивались на основе структурированной анкеты, вопросы которой относились к различным категориям: общие, правовые аспекты, пространственные аспекты, аспекты распространения информации и т.д.

Тестирование было проведено после завершения разработки модели 3D кадастра (на основе ISO FDIS 19152, LADM) и веб-прототипа для 3D-визуализации кадастровых объектов. Прототип представляет собой 3D-вьюер, который показывает кадастровые объекты в 3D пространстве и позволяет делать выбор, например, по кадастровому номеру, имени собственника, количеству комнат и т.д.

“Исследовательский проект” по 3D кадастру в России закончился в июле 2012 года. На основе положительного опыта проекта в целом и тестирования в частности были сформулированы рекомендации для внедрения 3D-кадастра в будущем, в том числе по совершенствованию российской нормативно-правовой базы и по организации 3D-кадастра.

Следующим шагом может стать применение рекомендаций к существующей ситуации. Что касается необходимых технических условий, должна быть создана производственная среда с более широкими функциональными возможностями, включая валидатор, СУБД для хранения данных, оперативное моделирование 3D-объектов из потока данных, получаемых из базы данных, и добавление к 3D-вьюеру возможности показа в 3D также граничащих объектов.

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1. PROJECT CONTEXT

The Russian-Dutch project "3D Cadastre Modelling in Russia" was implemented within the G2G Program of the Federal Service of State Registration, Cadastre and Cartography (Rosreestr) and Netherlands Kadaster from May 2010 to June 2012. A partner in the project was the Ministry of Economic Development of the Russian Federation. Project participants from Russia were Rosreestr, the Rosreestr Office in Nizhegorodskaya Oblast, Land Cadastral Chamber and the Federal Cadastral Centre "Zemlya". The Dutch side was represented by Netherlands Kadaster, Delft University of Technology, Grontmij Nederland B.V. and Royal Haskoning B.V.

At present, the system of state cadastre and real estate registration is based on the 2D representation of objects including land parcels, buildings and structures. However, the current approach does not cover all situations of the real 3D world. Examples of such situations impeding cadastre and rights registration are: multilevel complexes, intersections of various objects in space, underground and elevated engineering networks, etc.

The purpose of the Russian-Dutch 3D cadastre project was to evaluate possibilities of maintaining 3D cadastre (reflecting the real situation more accurately) for better cadastral record keeping and guarantees of rights.

The project included:

- the analysis of international experiences in 3D cadastres for selecting the most efficient solutions for their subsequent adaptation in the Russian environment;
- analysis of the Russian registration and cadastre legal framework for evaluating the feasibility of the introduction of 3D cadastre;
- creation of a 3D cadastre model for the Russian environment;
- development of a prototype basing on the 3D cadastre model;
- development of a data preparation process for 3D cadastre on pilot objects;
- testing of the prototype in conditions of a pilot region;
- carrying out of a training seminar for Rosreestr specialists and cadastral engineers;
- the drafting of proposals and recommendations on legal and organisational aspects to achieve better environment for the development of 3D cadastre in Russia.

Nizhegorodskaya Oblast was determined as a project pilot region and a number of cases was selected in Nizhny Novgorod, including:

Case 1: The Teledom building (see Figure 1). This is a multilevel office building with an underground parking and includes a large number of units with various types of registered rights. One part overhangs the road and another part is located above other building located on a neighbouring parcel. Only the basement is represented within the land parcel on a 2D map.

Figure 1. Some photographs showing the Teledom building and its environment

Case 2: An apartment complex with an underground parking (see Figure 2). This object is characterised by a large number of right holders, various types of rights and restrictions having been registered: ownership, lease, etc.

Case 3: A medium-pressure gas pipeline. It includes underground and elevated parts and is owned by Nizhegorodoblgaz.

The analysis of these use cases, looking at legal and organisational aspects, showed that although currently the Russian registration and cadastre legislation does not contain references to 3D objects, there are also no obstacles for the cadastral recording and registration of 3D parcels.

Figure 2. Some photographs showing the apartment complex with its underground parking

2. INFORMATION MODEL

The developed conceptual 3D-cadastre model is based on the ISO 19152 LADM. The model was adapted to the Russian environment and oriented to 5 types of property objects (land parcels, buildings, premises, structures and unfinished construction projects). Coming from the 2D cadastre and registration system existing in Russia, the option of a polyhedral legal 3D cadastre based on the representation of 3D objects as polyhedrons (volumes limited by flat faces) was selected as a working model. Curved surfaces of such objects as pipelines and cables are approximated by multi-polylines with diameters. For technical implementation, a solution involving the existing 2D portal and linking it with a new 3D-Viewer was selected. This solution is the most lightly implementable and requires minimal changes, based on functionality supported by the existing 2D portal.

For the development of the prototype and its testing on the cases, a package of data was acquired and processed according to requirements of the prototype, including:

- a topographic base map and a digital terrain model;
- cadastral data including boundaries and characteristics of cadastral blocks and land parcels;
- information on state registration of land parcels, buildings, premises and structures;
- technical documentation including technical passports with floor plans, etc.

In order to optimise the 3D cadastre prototype using floor plans and additional information, 3D models of buildings were developed reflecting volume characteristics of premises with the concurrent representation of respective right holders in conventional colours (see Figure 3).

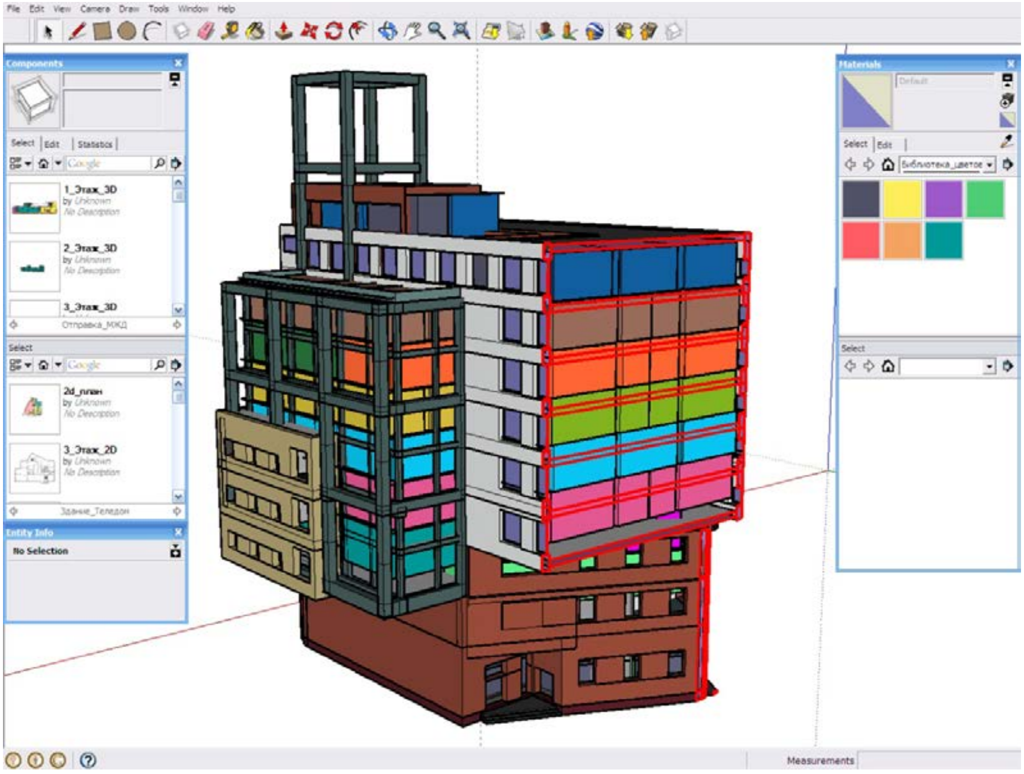

Figure 3. The Teledom building with the various 3D units being prepared in Google Sketchup

A summary attribute table including basic data from cadastre and the Register as well as technical characteristics of an object corresponds to each property unit. It includes:

A. for buildings (apartments):

- an object number according to the model;
- a storey (floor) number;
- a cadastral (if there is no such - conditional) number of an apartment;
- a cadastral (if there is no such - conditional) number of a building;
- a cadastral number of a land parcel;
- an address/location;
- an object function;
- an object name;
- a type of a right;
- a property category;
- a right holder;
- restrictions (encumbrances) of a right;
- an area of all parts of the building, m2;
- a total internal area, m2;
- a main internal area, m2;
- an additional internal area, m2;
- an average height, m;
- a volume, m3;
- a number of rooms;
- notes.

B. for structures (a gas pipeline):

- an object name;
- a function;
- a cadastral number of a land parcel;
- a cadastral (if there is no such – conditional) number of an object;
- an address;
- a length, m;
- a diameter, mm;
- a type of a right;
- a property category;
- restrictions (encumbrances) of a right;
- a right holder;
- notes.

3. PROTOTYPE

A prototype was developed to gather requirements for the functionality of a 3D cadastre viewer that could display both the 3D objects and the legal cadastral information of these objects. The prototype works with Internet Explorer and Firefox in combination with a plugin (BS Contact) for the visualisation and interaction with the 3D objects.

The interface consists of three main components including (see Figure 4):

i. the 3D Viewer itself, allowing various options for the visualisation of an object and its parts, including rotation, zooming, switching certain features on/off, and some special functions (e.g.: “identify” and “move floors”) for viewing more details;
ii. the Select window allowing various options for the selection and visualisation of 3D parcels within a 3D object pursuant given criteria;
iii. the Selection Results window allowing to view information about selected objects.

The prototype supports selection on multiple attributes (owner name, id of cadastral object, address, etc.); there is the option to show privacy data or not (depending on user's right of access), to show / hide layers such as the 2D cadastral map, topographic map, or areal/space image, and to show / hide elements in the 3D model itself: floor plans, walls or all elements that are not selected by the user at that moment. Per 3D object a link to a photograph or web page can be included.

The interface is for a large part dynamic: e.g. the language for names of information items in the Select and Selection Results windows can be configured to be either Russian or English, and if the information content of the legal cadastral data would change this does not require development of a new user interface.

A challenge during development of the prototype was especially how to uniquely link the 3D objects in the Viewer window (the units in the apartment buildings or the gas pipeline segments) with the legal cadastral data for those objects in the non-spatial part of the prototype. Another challenge was how to align the 3D models with the GIS data that was used for the 2.5D reference layers (ground parcels, and topographic layers combined with the Digital Elevation Model data set for that area).

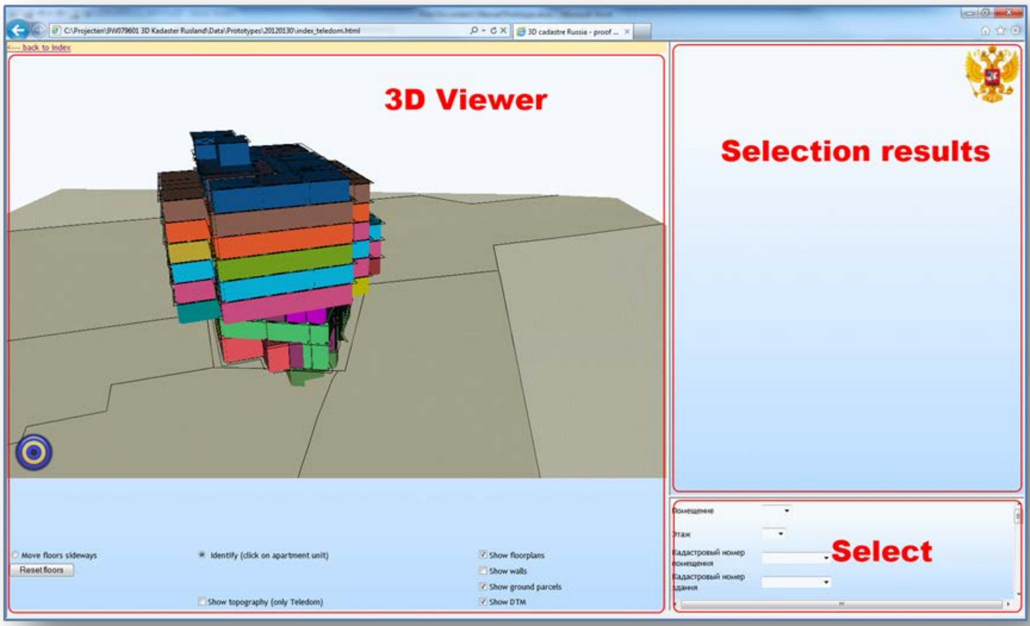

Figure 4. The web-based user-interface to interact and query 3D cadastral objects

4. PILOT AND EVALUATION

In April 2012 the pilot was organized by Dutch and Russian project WG members. Specialists from the Rosreestr system and cadastral engineers took part in the pilot. Purposes were to evaluate implemented prototype functionality, determine directions for future developments, and evaluate the feasibility of using 3D cadastre data both for better registration and cadastral recording and for expanding e-services to various groups of users.

The expert evaluation of testing results was made on the basis of a questionnaire drafted by the Dutch partners. Pilot participants completed the questionnaire consisting of 44 questions of which 7 were open questions (e.g. 'To what extent will the implementation of a 3D cadastre change the way you work?') and the others were formulated in the form of propositions (e.g. 'The law provides enough possibilities to accommodate a 3D cadastre') with three possible responses: disagree, agree or no opinion.

Results of the pilot and the questionnaire have shown positive attitudes to the possible introduction of a 3D cadastre in the Russian Federation. The suggestions made by the participants to have a better contact with users/clients indicates the interest and high expectations. The users/clients need to be timely informed and when needed trained in order to be able to handle expected changes and to obtain the real benefits by looking at the needs and views of potential users.

5. NEXT STEPS

Using results of the project and the prototype testing, recommendations were drafted on legal, organisational and technical aspects in order to establish favourable conditions in Russia for the introduction and maintenance of 3D cadastre in an operational real-world situation.

It should be noted that, with such conditions in place and supported by a production system, any appreciable additional costs of registering and recording 3D objects are not expected while, at the side of benefits, the gains are huge: a better description of objects and ownership rights, restrictions or responsibilities in the complex situation where the society is very concerned because of high real-estate values in dense urban areas. Also, using 3D cadastre is in line with the up-to-date innovative image of Rosreestr in the sphere of information technologies. This is why, after initial system development (extension), extra costs are practically not required and its introduction will not affect registration and cadastre workflows within Rosreestr. At this, it should be taken into consideration that new cadastral objects (new buildings or facilities) are often architecturally designed (with CAD) directly in 3D. Thus, with just little additional efforts (and clear guidelines), it is possible to use 3D objects for registration and cadastre.

For the technical aspects: more tests in an operational, real-world situation (but in a limited, controlled environment) are needed to establish the optimal system architecture and to compare alternative software solutions e.g. for the visualisation component. A production environment with more functionality should be developed, including: a validator, DBMS data storage, on-the fly creation of the 3D objects from a data stream obtained from the database, and an extension of the 3D viewer to show also neighbour units in 3D.

Validation of geometric quality and topological consistency is also an important topic. The validator should automatically check the 3D cadastral objects against the formal rules, before the new objects are accepted and stored in the DBMS. In the prototype this was omitted. However, in the production environment, proper data management tools can be used to implement some of the checks by using the correct geometric data type in the Oracle DBMS: the available (volumetric) solid type (see also Ledoux, et al. (2009); Thompson and Van Oosterom (2011)). Also, checks for potential conflicts with other 3D objects or columns implied by 2D surface parcel can be implemented efficiently in this environment. Some of the tasks of the validator include: check spatial aspects (flat faces, partition of space: no overlap or gaps in 2D and 3D, etc.); check consistency between spatial - legal/admin data; and check legal/admin attributes, proper transfer of rights between involved parties.

Further activities on the introduction of 3D cadastre and interaction with potential users both in Rosreestr and a wider circle of users will enable to identify the most effective ways of implementation and specify the list of information products to be generated using 3D cadastre data about complex real property objects.

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BIOGRAPHICAL NOTES

Galina Elizarova graduated from the All-Union Juridical Institute (Moscow). In 1982-2008 – various appointments at the Ministry of Justice of the Russian Federation. Since 2008 – Deputy Head of the Federal Service of State Registration, Cadastre and Cartography. Responsibilities: analysis and methodological support to the registration of real property rights and transactions, real property cadastre, registration and cadastral data distribution.

Sergey Sapelnikov graduated from the Bauman Moscow State Technical University. Since 2009 – Deputy Head of the Federal Service for State Registration, Cadastre and Cartography. Responsibilities: the Russian SDI, introduction of e-services into rights registration and cadastre, the digital Public Cadastral Map, development of cartography.

Natalia Vandysheva, PhD in Physics and Mathematics, graduated from the S.-Petersburg University (Russia). About 30-year experience in spatial data processing, digital mapping, GIS applications for land monitoring and cadastre, SDI. A project leader or an expert in many international projects (USA, UNEP, EU countries). In 2000-2012 – Chief of the Spatial Data Division, Federal Cadastral Centre “Zemlya” (FCC “Zemlya”); now – at Rostekhinventory-Federal BTI, Moscow.

Sergey Pakhomov graduated from the Computer-Aided Designing Department, Bauman Moscow State Technical University; since 2005 – at the FCC “Zemlya” (Moscow), one of principal developers and designers of the cadastral automated system (AIS GKN) and various software products for automation in the Federal Service of State Registration, Cadastre and Cartography. Now – Director of the Centre for Designing and Development of Automated Systems, FCC “Zemlya”.

Peter van Oosterom obtained an MSc in Technical Computer Science in 1985 from Delft University of Technology, The Netherlands. In 1990 he received a PhD from Leiden University for this thesis ‘Reactive Data Structures for GIS’. From 1985 until 1995 he worked at the TNO-FEL laboratory in The Hague, The Netherlands as a computer scientist. From 1995 until 2000 he was senior information manager at the Dutch Cadastre, where he was involved in the renewal of the Cadastral (Geographic) database. Since 2000, he is professor at the Delft University of Technology (OTB institute) and head of the section ‘GIS Technology’. He is the current chair of the FIG joint commission 3 and 7 working group on ‘3D-Cadastres’ (2010-2014).

Marian de Vries holds an MSc in Economic and Social History from the Free University Amsterdam, The Netherlands (VU). She worked some years at the Free University and the University of Nijmegen, then switched to become a software developer. Since 2001 she works as researcher at the Section GIS Technology, OTB, Delft University of Technology. Focus of her research is on distributed geo-information systems. She participated in a number of projects for large data providers in the Netherlands such as Rijkswaterstaat and the Dutch Cadastre, and in the EU project HUMBOLDT (Data harmonisation and service integration).

Jantien Stoter defended her PhD thesis on 3D Cadastre in 2004, for which she received the prof. J.M. Tienstra research-award. From 2004 till 2009 she worked at the International Institute for Geo-Information Science and Earth Observation, ITC, Enschede, the Netherlands (www.itc.nl). As associate professor at ITC she led the research group in the field of automatic generalization. She was project leader of an EuroSDR project on generalisation from 2005 till 2009. Since October 2009, she fulfils a dual position: one as Associate Professor at Section GIS technology at OTB and one as Consultant Product and Process Innovation at the Kadaster. From both employers she is posted to Geonovum (the National Spatial Data Infrastructure executive committee which develops and manages the geo-standards). The topics that she works on are 3D, information modeling and multi-scale data integration. Since January 2010 she leads the national 3D pilot that established a national 3D standard compliant to CityGML as a collaboration of about 60 partners. In November 2010 she received a VIDI grant, which is a prestigious award given by the Netherlands Organisation for Scientific Research (NWO) for excellent senior researchers to start a new research group (budget 800 000 Euros). Jantien has a wide national and international network in the areas of 3D modeling and automated generalization.

Hendrik Ploeger studied law at Leiden University and the Free University of Amsterdam, The Netherlands. In 1997 he finished his PhD-thesis on the subject of the right of superficies and the horizontal division of property rights in land. He is associate professor at Delft University of Technology (OTB Research Institute) and Leiden University, The Netherlands, and holds the endowed chair in land law and land registration at VU University of Amsterdam. His research expertise focuses on land law and land registration, especially from a comparative legal perspective.

Boudewijn Spiering obtained an MSc in Geodetic Engineering in 1991 from Delft University of Technology, The Netherlands. He is currently advisor GIS & ICT at Grontmij Nederland BV. Grontmij is a leading sustainable design, engineering and management consultancy active in the growth markets of water, energy, transportation and sustainable planning and design. His specializations include GIS, ICT, (Geo-) Information Management, Information Architecture, Data Management, Data Analysis, E-government, and various geo-applications for the (local) Dutch Government.

Rik Wouters holds a degree (MSc) in Agricultural Sciences from Wageningen University, The Netherlands. He worked for five years for FAO, where he had assignments in watershed management and forestry projects in Africa and Asia. In the Netherlands, he worked over 15 years in IT-projects. In 1996 he joined Kadaster and was responsible for large and complex

IT-projects among which a project dealing with the renewal of major parts of the land registration system. In 2006 he became regional manager for Kadaster International, where he is responsible for the regions Central and Eastern Europe and Asia. In recent years he carried out many review and advisory missions to ECA-countries for the World Bank, the Dutch Government and other donor-organisations.

Andreas Hoogeveen holds a degree (MSc) in Agricultural Sciences from Wageningen University, The Netherlands. After graduating Wageningen University in 1996, Andreas Hoogeveen started his career as partner with the consulting firm Optifield, focused at the use of ICT solutions and Geographic Information Systems for spatial planning. His knowledge of GIS and ICT was increased during the next two employers (Nieuwland and the Cadastre). Since 2005, Andreas Hoogeveen is Senior GIS Consultant with Royal Haskoning. The main expertise of Andreas Hoogeveen is providing solutions to content related issues. These solutions comprise spatial information systems, databases and web technology.

Veliko Penkov obtained an MSc in Civil Engineering at the University of Architecture, Civil Engineering and Geodesy in Sofia, Bulgaria. Since 1992 he works on various projects in Bulgaria and Russian Federation in the field of Cadastre, Land Registration, Geographic Information Systems, Land Consolidation, Quality Management, funded by World Bank, EU funds and bilateral programmes.

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